Luminosity and Data Quality

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NAF & FDR tutorial

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Data Quality

Data Quality

Data Quality is important!

If some subdetector is not working properly you don't want to use the data from unless you don't care.

There are three status states: red, yellow, green

When calculating the luminosity you can specify the subdetector status.

I am not sure what is in FDR1.

This should be the same as used for selection your data

→ tags

Luminosity: Hardware

Luminosity Measurement

Absolute luminosity:

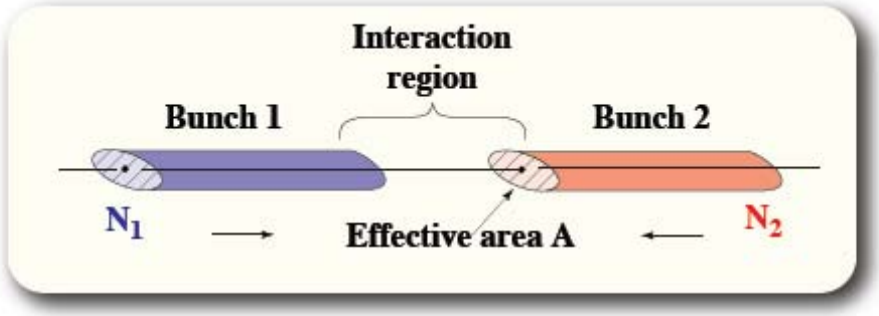
- **from machine parameters: 10-15%**
- **from electroweak gauge bosons production: 5-10%**
  - W, Z
- **from dedicated detector: 2-3%**
  - ALFA (2.6%)
  - measuring elastic pp scattering

Relative luminosity (monitor):

- **From dedicated detector:**
  - LUCID
  - measuring inelastic pp scattering

Luminosity from Machine

$$L = \frac{N_1 N_2 f}{A_{e\bullet}}$$



Beam intensities and crossing frequency are known with good accuracy
The effective overlap area A can be determined by scans in separation

Early LHC operation is without crossing angle and $\beta^* > \sigma_z$ (negligible hour-glass)
close to simplest case where $A_{\text{eff}} = 4\,\pi\,\sigma_x\,\sigma_y$

Need to know beam size:

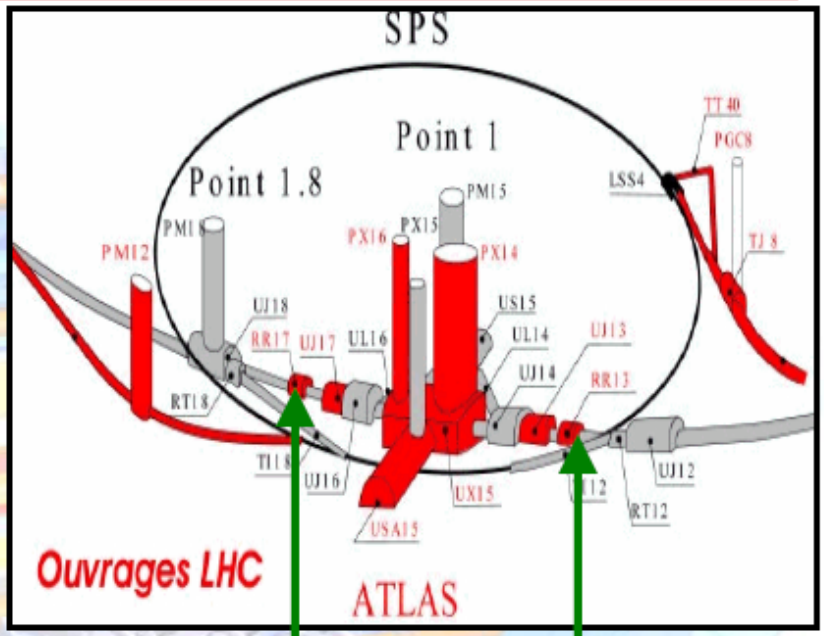
- **beam position monitors and scan in two planes**

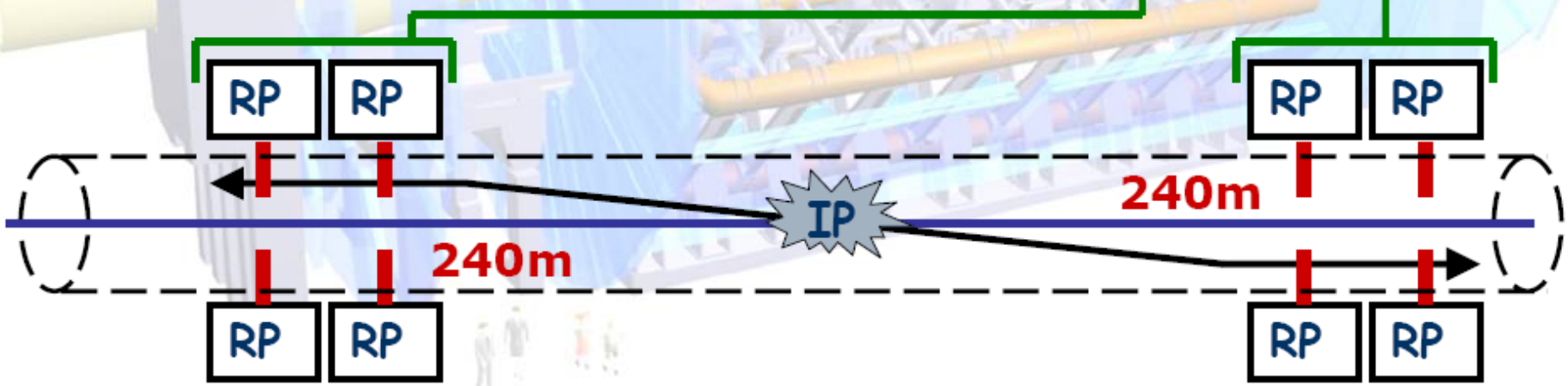
ATLAS Roman Pot Detectors
A Scintillating Fiber Tracker (ALFA)

ALFA = **A**bsolute **L**uminosity **F**or **A**TLAS

Elastic proton scattering

1. Determine the Absolute Luminosity in ATLAS
2. Physics Measurements
   - σ_{tot} and elastic scattering parameters
   - Tag protons for single diffraction…



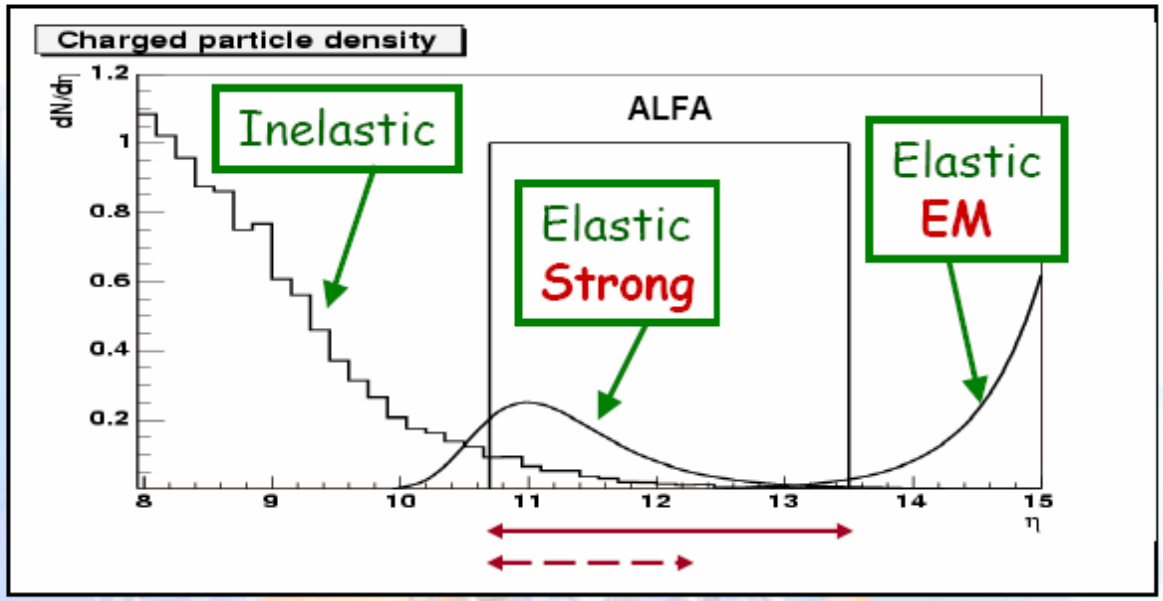


ATLAS Roman Pot Detectors
A Scintillating Fiber Tracker (ALFA)

Luminosity

Primary Method:
Coulomb Normalization

Secondary Method:
Optical Theorem



ALFA Coverage:

θ_{min} = 2.7 μrad
θ_{max} = 44.7 μrad

Large β* LHC Optics:

- Parallel to point focusing
- Distance wrt beam = 1-2mm
- Low-luminosity

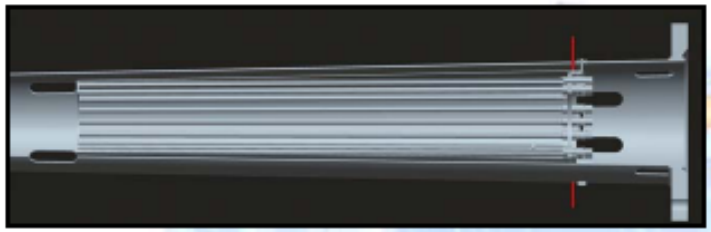
ALFA Design Goals:

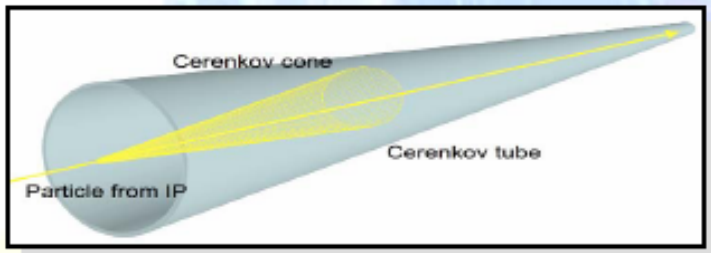
- $\sigma_{x,y}$ ~ 30 μm (< 130 μm)
- No significant non-active edge region (< 100 μm)
- Insensitive to RF from LHC beam

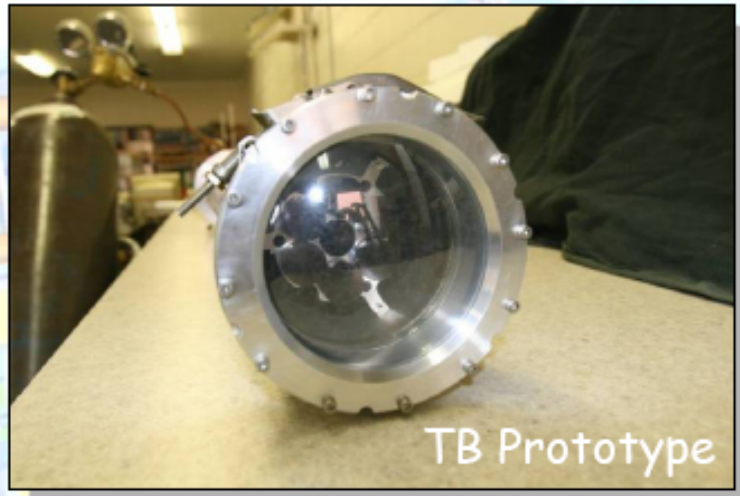
→ Scintillating Fiber Tracker

The ATLAS Luminosity Monitor (LUCID)

LUCID = LUminosity measurement using Cerenkov Integrating Detector







- Polished Aluminum tubes (Ø=1.5cm), filled with C4F10, surrounding the beam pipe and pointing at the IP (Z~17 m)
- Fits in available space and has low mass (< 25 kg/end)

- Cherenkov light reflected down the tube and read out by PMTs
- Pointing of the Al-tubes reduce signal from particles entering at large angles
- PMT signal Amplitude used to distinguish multi particles per tube
- Fast response from PMT allows to measure individual BCs

The basic concept

The rate of the pp interactions (R_{pp}) seen by LUCID is proportional to the luminosity (L):

$$R_{pp} = \mu_{LUCID} \cdot f_{BX} = \sigma_{pp} \cdot \varepsilon_{LUCID} \cdot L$$

Bunch crossing rate = $\frac{2808}{3564}$ (filled BX / total BX) x 40 Mhz

Number of pp interactions per bunch-crossing (BX) as measured by LUCID.

Efficiency (and acceptance) of LUCID to detect a pp interaction (~21% for single sided detection and ~5% for detection on both the A and C side).

Zero Counting — On and Off-line

Count bunch crossings with no interactions:

$$\mu_{LUCID} = -ln\left(\frac{N_{zeroBX}}{N_{totalBX}}\right)$$

Hit Counting — On and Off-line

Count the number of tubes with a signal (hit):

$$\mu_{LUCID} = \frac{< N_{hits/BX} >}{< N_{hits/pp} >}$$

Particle Counting — Off-line

Count the number of particles in LUCID by doing several cuts on the pulseheight distributions:

$$\mu_{LUCID} = \frac{< N_{particles/BX} >}{< N_{particles/pp} >}$$

The calibration

Example of hit counting:

Measured by the calibration method.

$$L = \frac{f_{BX}}{\sigma_{pp} \cdot \varepsilon_{LUCID}} \frac{< N_{hits/BX} >}{< N_{hits/pp} >}$$

Calibration constant

Measured at low luminosity
$\sim$0.29 according to Monte Carlo

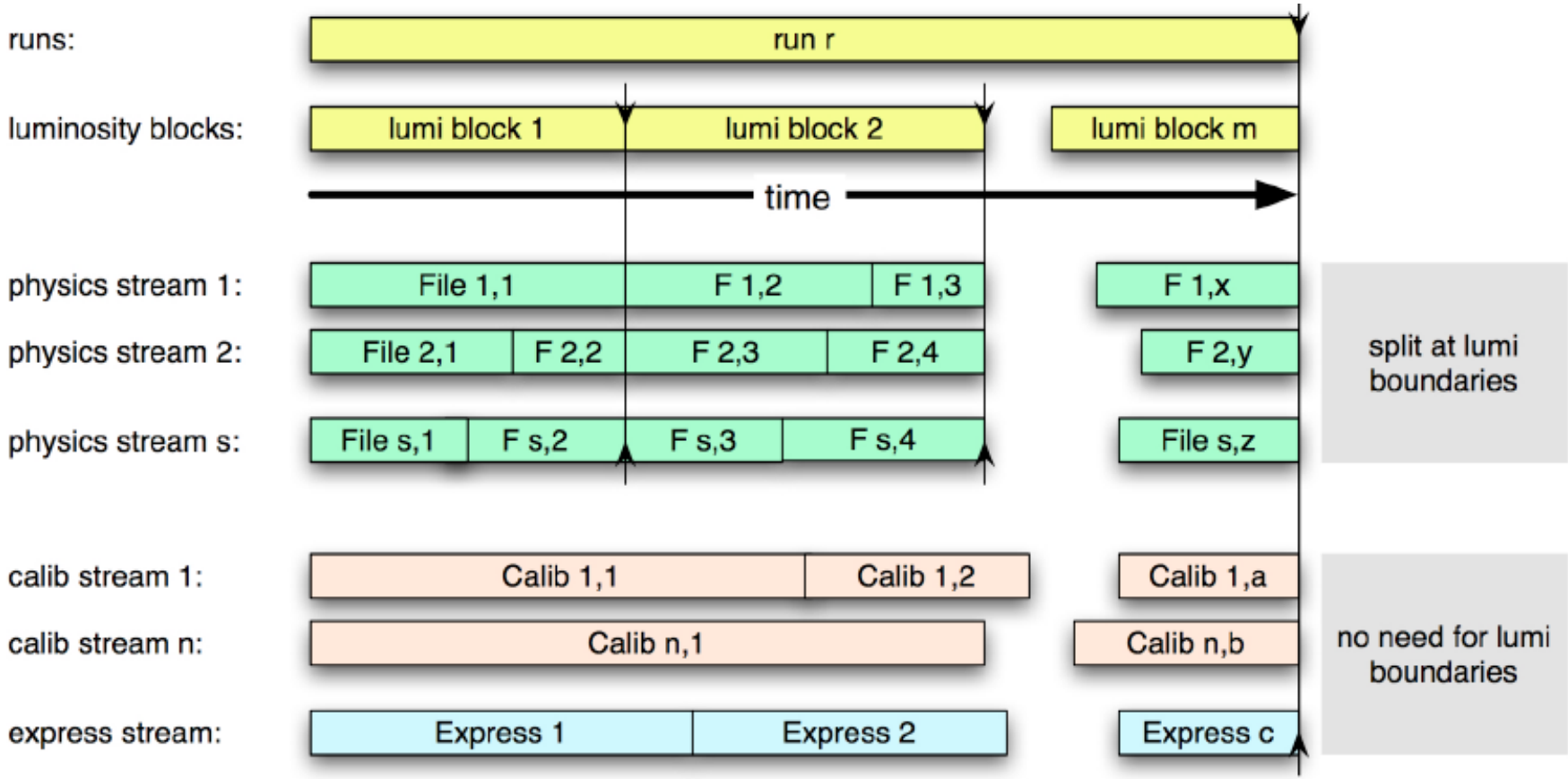
Initially. LHC Machine Parameters (Precision: $\sim$10%)

Medium term. Physics processes, W/Z & μμ/ee (Precision: $\sim$5-10%)

Final Roman Pot (ALFA) measurement (Precision: $\sim$2-3%)

Software

Lumi Blocks



- **Luminosity assumed to be constant per lumi block (~ minutes)**
- **Lumi blocks generated by trigger system**

Luminosity Calculation

- **Luminosity block to integrated luminosity mapping is done via a database (absolute luminosity and error can change after data taking)**

- **This is done by LumiCalc.py from LumiBlockComps package**

- **FDR1:**
  - Reprocessed FDR1 data has luminosity blocks in AOD
  - Database filled for FDR1

  → integrated luminosity can be calculated!

Try it out:

https://twiki.cern.ch/twiki/bin/view/Main/NAF07LumiTutorial